AIRS/AMSU/HSB Version 6 Level 2 Quality Control and Error Estimation

Edited by:
Edward T. Olsen

Contributed by:
Brian Kahn, Evan Manning
Jet Propulsion Laboratory, California Institute of Technology
John Blaisdell, Lena Iredell, SAIC/GSFC, Joel Susskind, GSFC

February, 2012
Version 1.0

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, CA

Submit Questions to:
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1 Level 2 Quality Indicators

1.1 Major Quality Indicator Change for V6

We have made a major change in the presentation of the quality indicators for V6. While there are only minor changes to the logic used to set the quality indicators, the presentation to the user is entirely different. In V5, users were asked to apply a set of about a dozen quality indicators to the various products. This has proved problematic, thus **for V6 each retrieved physical quantity now has its own matching quality indicator and error estimate. The names of the quality indicators are the same as the name of the corresponding parameter with "_QC" appended to the name. Where a parameter is an array, such as TAirStd, the corresponding quality indicator TAirStd_QC is also an array of the same dimension. Most of the previous quality indicators Qual_Temp_Top, etc., have been removed from the V6 output to eliminate confusion. The meaning of QC values 0, 1 and 2 are unchanged from what they were in V5.**

The error estimates continue the V5 convention of having the name of the parameter with "Err" appended, for this example an array named **TAirStdErr**.

We hope that this change will alleviate any difficulty in determining which flag applies to which quantity. This change also allows for future expansion of the quality control logic to more precise level-by-level analysis.

The marking of temperature and water profiles by **PBest** and **PGood** continues as in V5. **Users are encouraged to use PBest and PGood for temperature and water vapor if it simplifies their analysis.**

1.2 Introduction

The AIRS Level 2 Standard Product contains many retrieved parameters, and each has an associated quality indicator the researcher should use to filter and subset the specific geophysical parameter of interest. The possible values are:

Quality = 0 => "BEST"
Data products individually meet our accuracy requirements and may be used for comparison with in situ measurements, data assimilation and statistical climate studies.

Quality = 1 => "GOOD"
Data may be used for statistical climate studies, as they meet the accuracy requirements only when temporally and/or spatially averaged. Note that relying solely on Quality = 0 cases when generating monthly mean fields may result in significant sampling biases. Users may find it useful to compare the number of time the field was observable with the number of retrievals of that field over the sampling period.

Quality = 2 => "DO NOT USE"
While we do not recommend use of any Quality = 2 data, we recognize that it may be the only data available in the vicinity of hurricanes and storm fronts. Users should carefully check the error estimates on the individual soundings and proceed with great caution if they contemplate making use of these data. Note that the yield in difficult regions is much greater in V6 than in V5 and users may now be able to avoid Quality = 2 data altogether.

We create our Level 3 products by combining Quality = 0 and Quality = 1 data, averaged over the appropriate spatial area (1°x1° deg grid) and time period (daily, 8 day and calendar month).

The legacy variable **RetQAFlag** was a concatenation of the limited quality information present in previous releases. It has been removed from the V6 delivery, as it is not compatible with the current quality definitions.

Retrieved parameters are generated for each AMSU FOV. In most cases, complete soundings are produced using both AIRS and AMSU observations. If satisfactory infrared cloud cleared radiances cannot be produced, all surface and atmospheric retrieval products are flagged Quality = 2 (do not use).

Whenever the IR/MW retrieval is completed, many parameters, including stratospheric temperature, are marked Quality = 0 at high altitudes. At some level in the atmosphere the temperature profile error estimates may exceed a threshold, and **PBest** is set to that pressure level. Deeper in the atmosphere the error estimates may exceed a larger threshold and **PGood** is set to that pressure level. The surface and atmospheric retrieval products are then flagged as

described in the remainder of this document. More details of the algorithmic flow can be found in the document **V5_L2_Retrieval_Flow.pdf**.

In V5, if clouds could be obtained from the startup state, the cloud related products including outgoing longwave radiation (OLR) and precipitation estimate were flagged quality = 1. Since the IR/MW retrieval yield is markedly greater in V6, such cases are now marked Quality = 2, and Quality = 1 describes a different subset of cases. For V6, if the retrieved surface temperature differs from the first guess (provided by the neural net) surface temperature by five degrees or more, the surface parameters are marked Quality = 2 and the clouds and OLR are computed from the neural net surface combined with the IR/MW retrieved atmosphere. The OLR and clouds are marked Quality = 1 for these cases.

1.2.1 Combined MW/IR and IR-Only Retrieval Data Sets

V6 processing is also executed at the GES DISC in AIRS-only mode (i.e., IR-Only retrieval) in anticipation of the possible loss of additional AMSU channels. The Aqua spacecraft expendables are forecast to be sufficient to allow operation until early 2022, and we anticipate that the AIRS (IR) instrument lifetime will be determined by the Aqua lifetime but that the AMSU (MW) instrument lifetime will be shorter. Thus at some point in the future the combined IR/MW retrieval flow is expected to cease but the IR-Only retrieval flow will continue. In this event the microwave products will be unavailable. The additional quality control changes are minimal and we include them in this document for reference. **Researchers should never combine MW/IR and IR-Only retrievals in their analyses, for the statistical sampling and quality of the two data products are different.** We recommend the use of one or the other, but never both combined. Based on our monitoring of the instrument housekeeping data, we anticipate that V6 combined MW/IR retrievals should be available into the indefinite future. We have seen no indication that other AMSU channels are in jeopardy.

1.2.1.1 Failure of HSB and AMSU Channels 4 and 5

- HSB (scan mechanism) failed on 5 February 2003
- AMSU Channel 4 NeDT exceeded 1 K late in September 2007 and rose sharply thereafter. It was excluded from V5 processing on 1 Oct 2007.
- AMSU Channel 5 NeDT exceeded 1 K early in January 2011 and rose above 2 K in December 2011. It was never excluded in V5 Processing.
- AMSU Channel 7 exhibited excessive noise at launch and was never used in any version of the physical retrieval.

For continuity throughout the mission, V6 AMSU+AIRS processing does not use radiances of AMSU channels 4 and 5. On the other hand, V6 AMSU+HSB+AIRS processing DOES use radiances of AMSU channels 4 and 5 to provide maximum quality retrievals, particularly for moisture.

1.2.2 Level 2 MW-Only Retrieval Quality Indicators

1.2.2.1 MW-Only Temperature Profile Quality Indicators

Standard product:

TAirMWOnlyStd_QC
sfcTbMWStd_QC
EmisMWStd_QC

Support product:

TAirMWOnly_QC

The part of the **TAirMWOnlyStd** profile at pressures equal to or greater than 201 hPa is set by examining the bits in **MW_ret_code** corresponding to tropospheric temperature channels (AMSU channels #5 through #8) to detect:

- Excessive residuals
- Excessive liquid water (> 0.5 kg/m^2)
- Insufficient valid channels
- Numerical error
- Emissivity not within the interval [0,1] for any AMSU-A channel

If any of these five bits are set, then **TAirMWOnlyStd_QC** and **TAirMWOnly_QC** for those levels are set to Quality = 2; otherwise they are set to Quality = 0. **sfcTbMWStd_QC** and **EmisMWStd_QC** are also set by this check, with the additional modifications that in the absence of HSB, array elements 6 and 7 (corresponding to 150 GHz and 183.31 GHz) are marked Quality = 2 and contain fill values (-9999). In the absence of radiances from AMSU channels 4 and 5, array element 4 (corresponding to 52.8 GHz) contains values for both **sfcTbMWStd** and **EmisMWStd,** but **sfcTbMWStd_QC(4)** is set to Quality = 2 to reflect the absence of an actual measurement here.

The part of the**TAirMWOnlyStd** profile at pressures less than 201 hPa is set by examining the bits in **MW_ret_code** corresponding to stratospheric temperature channels (AMSU channels #9 through #14) to detect:

- Excessive residuals
- Insufficient valid channels
- Numerical error

If any of these three bits are set, then **TAirMWOnlyStd_QC** and **TAirMWOnly_QC** for those levels are set to 2; otherwise they are set to 0.

Thus, for these two quality indicators:

0 = associated profile segment accepted

1 … never occurs

2 = associated profile segment rejected, researchers should not use

1.2.3 MW-Only Moisture Profile and Cloud Liquid Water Quality Indicator

Standard product:

totH2OMWOnlyStd_QC
totCldH2OStd_QC

Support product:

H2OCDMWOnly_QC
GP_Height_MWOnly_QC
lwCDSup_QC

These quality flags are set according to the V5 rules for **Qual_MW_Only_H2O,** which is no longer output in V6. The failure of HSB degraded various moisture research products, and this quality factor is set in part by the availability of HSB data. It is set by examining the bits in **MW_ret_code** for channels affecting the moisture retrieval to detect:

- Excessive residuals
- Excessive liquid water (> 0.5 kg/m2)
- Insufficient valid channels

- Numerical error
- Emissivity not within the interval [0,1] for any AMSU-A channel

If any of these five bits are set, then these quality flags are set to 2.

If the test on **MW_ret_code** yields no fault, an additional test is performed. If HSB data are present these quality flags are set to 0. If HSB data are not present and **MWSurfClass** = 0 or 2, these quality flags are set to 1, and they are set to 2 for all other surface types. Note that quality = 1 here constitutes the best level of quality that can be achieved when HSB data are not available.

The quantity **GP_Height_MWOnly** depends on both temperature and water, working upward from the surface. **GP_Height_MWOnly_QC** for the entire profile is set to the higher of **TAirMWOnly_QC(surface)** or **H2OCDMWOnly_QC(surface)**.

Users should filter MW-Only moisture retrievals according to these quality values as follows:

0 = (i.e., HSB data used) use column totals and support product profiles

1 = (i.e., HSB data not used) use only the column totals

2 = moisture retrieval rejected, do not use

1.2.4 Level 2 Combined IR/MW Retrieval Quality Indicators

1.2.4.1 Profile Quality Indicator

V5 introduced and V6 continues the determination of two characteristic pressures that define the quality of the temperature profile of an accepted IR/MW retrieval. While determined by the temperature retrieval error estimates, these values are also applied to the water profiles:

- **PBest** The profile from the top of the atmosphere (TOA) to this pressure level is of best quality (i.e., Quality = 0).
- **PGood** The profile beneath the level of **PBest** down to this pressure level is of good quality (i.e., Quality = 1). The temperature profile beneath the level of **PGood** is assigned Quality = 2 (do not use). Note that **PBest** and **PGood** may be identical. In this case the temperature profile for altitudes above and including that pressure level is assigned Quality = 0 whereas the temperature profile for altitudes below that pressure level is assigned Quality = 2.
- **nBestStd** The index of the lowest altitude level of the **pressStd** and **TAirStd** profiles for which the quality is “best”. Levels whose indices are in the range i = **nBestStd**, 28 are therefore marked Quality = 0. It is set to a value of 29 to indicate that none are “best”. Take note that **nBestStd** is 1-based (as are arrays in FORTRAN and MATLAB) rather than 0-based (as are arrays in C and IDL).
- **nGoodStd** The index of the lowest altitude level of the **pressStd** and **TAirStd** profiles for which the quality is “good”. Levels whose indices are in the range i = **nGoodStd**., **nBestStd**-1 are therefore marked Quality = 1. It is set to a value of 29 to indicate that none are “good”. Take note that **nGoodStd** is 1-based (as are arrays in FORTRAN and MATLAB) rather than 0-based (as are arrays in C and IDL).

Corresponding values **nBestSup** and **nGoodSup** for the support levels are found in the support product, and they are each set to a value of 0 to indicate that none are “best” or “good” respectively.

Users take note that the indices of the levels and layers of profiles in the standard product increase from surface to TOA (i.e., index 20 is at lower altitude than index 21); conversely, the indices of the levels and layers of profiles in the support product increase from TOA to surface (i.e, index 50 is at higher altitude than index 51).

The methodology for determining **PBest** and **PGood** is discussed in detail at the end of this document.

In all cases, the quality for temperature profile levels at p > **PGood** is assigned Quality = 2 (do not use).

The legacy temperature profile quality indicators from V4 that were maintained in V5 **(Qual_Temp_Profile_Top, Qual_Temp_Profile_Mid, Qual_Temp_Profile_Bot)** have been deleted in V6 and replaced with the level-by-level flags for the temperature variables, compatible with the definitions of **PBest** and **PGood.**

1.2.4.2 Important Note Concerning Contamination due to Dust and Volcanic Ash

Physical retrievals can be seriously compromised if the AIRS field of regard is contaminated by dust and/or volcanic ash. Users should always include the **dust_flag**, **dust_score** and **BT_diff_SO2** in their quality control filtering of data.

The dust detection algorithm is only valid over ocean fields of regard. It should be useful for filtering data contaminated by dust, especially in the Saharan Air Layer (SAL) over the Atlantic Ocean. ***We recommend users ignore retrievals over oceans for which dust_score ≥ 380 or dust_flag = 1, regardless of the values of any QA indicators****.*

We also recommend that users filtering to select high quality data avoid AIRS fields of regard for which **BT_dif_SO2** ≤ 6 K. Those fields are likely contaminated by volcanic ash.

1.3 How Combined IR/MW Quality Control is Set Upon Completion of Final Retrieval

1.3.1 Preliminary Determinations

There are some preliminary determinations made which are then used to set the quality indicators. The first decision is between the final retrieval and the fallback state. The fallback state is chosen whenever the final retrieval fails to complete.

If the fallback case is selected, all Combined IR/MW quality indicators are set equal to 2, and none of the following logic is applied.

In V5, an internal variable **constituent_good** was determined using the predicted error of the water profile. In V6, this condition has been replaced by a test requiring that the profile has Quality = 1 all the way to the surface (**PGood** = **PSurfStd**), leading to greater consistency in quality flagging between the total precipitable water and the water profile products.

The degrees of freedom for the CO (**CO_dof**) and CH4 (**CH4_dof**) retrievals are used directly as outlined below. The residual for the CH4 retrieval (**CH4_Resid_Ratio**, i.e., the ratio of the CH4 residual to the expected noise) is also used in CH4 quality control.

Limit checks are made to detect values far out of range of the range of validity of the Rapid Transmittance Algorithm (RTA) used for forward calculation of radiances from the physical state. Values of bad_<component> are flagged in the L2 Support Product if they are out of the validated RTA range by 25% or 50% of that range in log() space of the particular retrieved component.

- bad_temps - If 4 or more levels have temperatures 25% out of range, then bad_temps is set. Levels that are 50% out of range count double, so only two such are required to set bad_temps.

If the test on the temperature profile succeeds, then additional tests are carried out for each constituent. (See Appendix I for limits).

- bad_H2O and bad_O3 – set if 5 or more layers are 50% out
- soso_H2O and soso_O3 – set if 5 or more layers are 25% out or 1 or more layers are 100% out.

If either H2O or O3 is “bad”, then all constituents (but not temperature) are marked QC = 2. If either is “soso” then all constituent QC is initiated at QC=1.

If psurf or tsurf is 25% out of range then QC = 1 for all surface quantities.

The individual quality indicators are then set as follows for cases where the retrieval completes (combined IR/MW or IR-Only).

1.3.2 Temperature products

In V5, **Qual_Temp_Profile_Top, Qual_Temp_Profile_Mid,** and **Qual_Temp_Profile_Bot** reflected the vertical position of **PBest** and **PGood**. In V6, these variables have been replaced by a QC flag at every level reflecting whether the level is at an altitude above **PBest** (Quality = 0), between **PBest** and **PGood** (Quality = 1), or beneath **PGood** (Quality = 2) as discussed in the introduction. The profiles for which retrievals are not available are marked Quality = 2 at all levels.

Standard product:

TAirStd_QC = Profile Quality

TSurfAir_QC = Profile Quality(nSurfSup)

PTropopause_QC = Profile Quality(PTropopause + 50 mb)

T_Tropopause_QC = Proflile Quality(PTropopause + 50 mb)

Support product:

TairSup_QC = Profile Quality

1.3.3 Water Products

In V5, a single water quality flag **Qual_H2O** contained the quality for the total precipitable water. We had advised users that the water profile was usable above **PBest** but we had no specific water quality flag to indicate this.

In V6, these variables have been replaced by a QC flag at every level reflecting whether the level is at an altitude above **PBest** (Quality = 0), between **PBest** and **PGood** (Quality = 1), or beneath **PGood** (Quality = 2) as discussed in the introduction. The profiles for which retrievals are not available are marked Quality = 2 at all levels.

Despite any quality flagging, we have very little sensitivity to water in the stratosphere. Water values above the 100 hPa level reflect climatological assumptions and contain no actual retrieved information.

Standard product:

H2OMMRStd_QC = Profile Quality
H2OMMRLevStd_QC = Profile Quality
H2OMMRSurf_QC = Profile Quality(nSurfSup)
totH2OStd_QC = Profile Quality(nSurfSup)
RelHum_QC = Profile Quality
RelHumSurf_QC = Profile Quality(nSurfSup)
RelHum_liquid_QC = Profile Quality
RelHumSurf_liquid_QC = Profile Quality(nSurfSup)
H2OMMRSat_QC = Profile Quality
H2OMMRSatLevStd_QC = Profile Quality
H2OMMRSatSurf_QC = Profile Quality(nSurfSup)
H2OMMRSat_liquid_QC = Profile Quality
H2OMMRSatLevStd_liquid_QC = Profile Quality
H2OMMRSatSurf_liquid_QC = Profile Quality(nSurfSup)
GP_Tropopause_QC = Profile Quality(nSurfSup)
GP_Height_QC = Profile Quality(nSurfSup)
GP_Surface_QC = Profile Quality(nSurfSup)

Support product:

H2OCDSup_QC = Profile Quality
H2OMMRLevSup_QC = Profile Quality
H2OMMRSatLevSup_QC = Profile Quality
H2OMMRSatLevSup_liquid_QC = Profile Quality
H2O_VMR_eff_QC = Profile Quality
GP_HeightSup_QC = Profile Quality(nSurfSup)

1.3.4 Surface Products

The surface quality **Qual_Surf** is set by testing the surface temperature error estimate, **TSurfStdErr** against a threshold.

Over Ocean:

Qual_Surf = 0 if **TSurfStdErr** < 1.1 K (1.2 K in AIRS-only)

Qual_Surf = 1
if Lat > -40° and **TSurfStdErr** < 1.4 K
if Lat < -60° and **TSurfStdErr** < 2.0 K
if -60° ≤ Lat ≤ -40° and **TSurfStdErr** < a value linearly interpolated in latitude from 1.4 K to 2.0 K

Qual_Surf = 2 if **TSurfStdErr** fails test

Over Land and Frozen Cases:

Qual_Surf = 1 if **PGood = PSurfStd** and **TSurfStdErr** < 7.0 K

Qual_Surf = 2 otherwise

Standard product:

TsurfStd_QC = Qual_Surf
emisIRStd_QC = Qual_Surf

Support product:

Emis50GHz_QC = Qual_Surf
Effective_Solar_Reflectance_QC = Qual_Surf

1.3.5 Geopotential Products

Geopotentials are calculated by integrating temperature and water vapor from the surface up. Therefore no geopotential fields are good unless the quality of the profile is good all the way from the top of the atmosphere down to the surface. All **GP*_QC** are set equal to **TAirSurf_QC**, the quality of surface air temperature.

Standard product:

GP_Surface_QC = TAirSurf_QC
GP_Height_QC = TAirSurf_QC
GP_Tropopause_QC = TAirSurf_QC

Support product:

GP_Height_Sup_QC = TAirSurf_QC

1.3.6 Ozone Products

If **PGood = PSurfStd**, then all ozone products are marked Quality = 0
Otherwise, all ozone products are marked Quality = 2

Because the ozone channels all see the surface, we do not in this version discriminate a “good” (Quality = 1) portion of the profile from a “best” (Quality = 0) portion of the profile; the entire profile is either Quality = 0 or Quality = 2.

Standard product:

totO3Std_QC
O3VMRStd_QC
O3VMRLevStd_QC
O3VMRSurf_QC

Support product:

O3CDSup_QC
O3VMRLevSup_QC
O3_VMR_eff_QC

1.3.7 Carbon Monoxide Products

If **PGood = PSurfStd**, and **CO_dof** > 0.5, then all CO products are marked Quality = 0.

If **PGood = PSurfStd**, and 0.5 >= **CO_dof** > 0.4, then all CO products are marked Quality = 1.

Otherwise, all CO products are marked Quality = 2.

Standard product:

CO_total_column_QC
COVMRLevStd_QC
COVMRSurf_QC

Support product:

COCDSup_QC
COVMRLevSup_QC
CO_VMR_eff_QC

1.3.8 Methane products

Initial QC tests:

If **PGood = PSurfStd** and **CH4_Resid_Ratio** < 1.5 and **CH4_dof** > 0.5, then all CH4 products are marked Quality = 0.

If **PGood = PSurfStd** and **CH4_Resid_Ratio** < 1.5 and 0.5 >= **CH4_dof** > 0.4, then all CH4 products are marked Quality = 1.

Otherwise, all CH4 products are marked Quality = 2.

Additional QC tests:

The CH4 absorption band is within the water vapor absorption band near 7.6 mm, and thus the quality of the moisture product impacts that of the CH4 product. Therefore, if **totH2OStd_QC** = 1, we set all CH_4 quality flags to 1 if:

- **CH4_Resid_Ratio** ≥ 1.0, or
- **PGood** ≤ 610 hPa

We found the contamination of CH_4 retrievals is mainly from low water clouds. Under the condition of **totH2OStd_QC** = 1, we set all CH_4 quality flags to 2 when the cloud fraction among the 9 AIRS spots within a retrieval FOV are mainly water clouds or they are very different. The test for water clouds uses **cloud_phase_3x3** (located in the L2 Support Product).

We recognize there remains a scan angle dependence of retrieved CH_4 at altitudes above the 200 hPa level in the tropics. To minimize its impact upon research, we set Quality=2 for the two most extreme san angle retrievals at the beginning and end of each scan set (i.e., retrieval FOVs 1, 2, 29 and 30) whenever **PTropopause** ≤ 100 hPa.

Standard product:

CH4_total_column_QC
CH4VMRLevStd_QC
CH4VMRSurf_QC

Support product:

CH4CDSup_QC
CH4VMRLevSup_QC
CH4_VMR_eff_10func_QC

1.3.9 CO2

The CO2 appearing in the L2 Support Product is not a retrieved quantity; rather, it is the first-guess CO_2 concentration (parts per million by volume) used during the Level 2 physical retrieval of other atmospheric parameters. A subsequent algorithm ingests the Level 2 retrieval products and is initialized with the same first-guess CO_2 value to produce the AIRS CO_2 product separately.

The first-guess value of the CO_2 concentration (parts per million by volume) is calculated for each footprint via the following algorithm:

$$CO2\_ppmv(t) = 371.789948 + 2.026214 \times \Delta t$$

Δt is the time between the current FOV and 0^{hr} UT on Jan 1, 2002

$$\Delta t = \left(t_{FOV} - t_{0UT\_01Jan02}\right)$$

and is expressed in fractions of a year. This linear fit to the marine GLOBALVIEW-CO2 from start of 2002 to end of 2009 is applied globally to avoid non-linear effects in the RTA calculation that could arise from very large differences between a fixed assumed and the true CO_2 concentration over the time span of the mission, while at the same time not introducing geospatial or seasonal variations that might leak into the post-processing CO_2 retrieval.

Support product:

CO2ppmv
CO2ppmv_QC

CO2ppmv_QC is always set to 2 in V6 to indicate that it is not a retrieved quantity.

1.3.10 Cloud and OLR products

For nearly all these products:

If we accept a final retrieval, Quality = 0.

If we accept a final retrieval, but the final retrieved surface temperature differs from the neural net surface temperature by > 5 K, the clouds and OLR are calculated from the neural net, and these values are set to Quality = 1.

In the event that the cloud retrieval is not completed this indicator is set to Quality = 2.

The clear sky OLR products require an accurate retrieval to the surface, so their QC are set as follows. If the profile quality is good to the surface (**PGood = PSurfStd**), the internal indicator, Qual_clrolr_QC is set to 0; otherwise this indicator is set to 2. The reported variables, **clrolr_QC** and **spectralclrolr_QC** are set equal to this indicator.

Cloud_phase_3x3 is a derived parameter, rather than a retrieved parameter and therefore does not have a _QC field associated with it. Instead, whenever the cloud phase cannot be determined the value of cloud_phase_3x3 is set to -9999 and the low bit of **cloud_phase_bits** is set. These are cases where QC indicates that required inputs were of low quality.

Reasons for cloud_phase_3x3 to be set to -9999 are:

1) QC=2 for surface emissivity
2) QC=2 for cloud fraction
3) All radiances = -9999 for all channels in any band.

Standard product:

CldFrcTot_QC
CldFrcStd_QC
PCldTop_QC
TCldTop_QC
PCldTopStd_QC
TCldTopStd_QC
olr_QC
olr3x3_QC
clrolr_QC (= Qual_clrolr)

Support product:

CldEmis_QC
CldRho_QC
IR_Precip_Est_QC
IR_Precip_Est3x3_QC
spectralolr_QC
spectralclrolr_QC (= Qual_clrolr)

1.3.11 Cloud Cleared Radiances

The channel-by-channel quality flags are new in V6. The error estimates for each channel (**radiance_err**) are converted to brightness temperature error estimates, and the quality flags are then set as follows:

= 0 if $\Delta T < 1.0$ K
= 1 if $1.0 <= \Delta T < 2.5$ K
= 2 otherwise

Cloud-clearing product:

radiances_QC

1.3.12 QC Indicators for Other Products (in Support Product)

Except as noted, all of these products require **PGood = PSurfStd** or they have Quality = 2.

Support product:

bndry_lyr_top_QC is set to 0 unless:

1) If SurfClass is not 2 (nonfrozen ocean) then bndry_lyr_top_QC is set to 2
2) If a noncontiguous layer has a gradient over 97% of the value of the gradient for the chosen layer then bndry_lyr_top_QC = 1
3) If the relative humidity input to the calculation is < 0 or > 3 then bndry_lyr_top_QC = 1.
4) Bndr_lyr_top_QC is set never to be lower (better) than TSurfAir_QC.
5) If RelHumSUrf > 100% then bndry_lyr_top_QC = 2.

Course Climate Indicator (CCI) QC:

Tropo_CCI_QC

Strato_CCI_QC

These flags are set the same way as the total precipitable water flag; best if **PBest** is at the surface, else 1 if **PGood** is at the surface, else 2.

ice_cld_opt_dpth_QC

=0 if ice_cld_opt_dpth_ave_kern ≥ 0.8
and ice_cld_fit_reduced_chisq < 10.0

=1 if ice_cld_opt_dpth_ave_kern < 0.8 or ice_cld_fit_reduced_chisq ≥10.0

=2 if ice_cld_opt_dpth_ave_kern < 0.8
and ice_cld_fit_reduced_chisq ≥10.0

ice_cld_eff_diam_QC

=1 if ice_cld_eff_diam_ave_kern ≥ 0.8
and ice_cld_fit_reduced_chisq < 10.0

=2 if ice_cld_eff_diam_ave_kern < 0.8 or ice_cld_fit_reduced_chisq ≥ 10.0

=0 NEVER. We chose to make stricter quality control for the ice cloud effective diameter and no fields satisfy the criteria.

ice_cld_temp_eff_QC

=0 if ice_cld_temp_eff_ave_kern ≥ 0.8
and ice_cld_fit_reduced_chisq < 10.0

=1 if ice_cld_temp_eff_ave_kern < 0.8 or ice_cld_fit_reduced_chisq ≥10.0

=2 if ice_cld_temp_eff_ave_kern < 0.8
and ice_cld_fit_reduced_chisq ≥10.0

The following two parameters depend on L1B radiance quality instead of L2 quality flags:

BT_diff_dust_LR_QC

= 2 for bad L1B values in either primary band (830-835 cm^{-1}, 955-965 cm^{-1})

= 1 for bad L1B value in the secondary band (1219.5-1124 cm^{-1}), or land, or cold

= 0 otherwise

BT_diff_SO2_QC

= 2 if either L1B channel is bad

= 0 otherwise

1.3.13 Other QC Indicators

Standard product:

PsurfStd_QC

= 0 if surface pressure from timely forecast (normal)

= 1 if surface pressure from climatology/topography

= 2 only occurs if satellite is not in normal operations

This is not a retrieval quality flag, but instead reflects the input source of the surface pressure.

2 Combined IR/MW Retrieval Error Estimation

This section describes how **PGood** and **PBest** are determined in detail.

The following 14 quantities (also contained within the Level 2 Standard Product) are primarily indicative of values of different internal convergence tests. All differences are absolute values. They are used via regression to estimate errors in the surface temperature, air temperature profile at 100 levels, and the total water burden:

1.	**totcloudh2o**	total liquid water
2.	**CC1_Resid**	fit parameter for first cloud clearing
3.	**CCfinal_Resid**	fit parameter for final cloud clearing
4.	**CCfinal_Noise_Amp**	amplification factor for SECOND cloud clearing
5.	**AMSU_Chans_Resid**	observed minus calculated for AMSU channel 5 in final state
6.	**Tdiff_IR_MW_ret**	difference in lowest 2 km between last AMSU and IR retrievals
7.	**Surf_Resid_Ratio**	ratio of residual in surface retrieval to expected noise
8.	**Temp_Resid_Ratio**	ratio of residual in temperature retrieval to expected noise
9.	**CC1_noise_eff_amp_factor**	effective noise amplification factor in first cloud clearing
10.	**CC_noise_eff_amp_factor**	effective noise amplification factor in last cloud clearing
11.	**TSurfdiff_IR_4CC2**	difference between final Tsurf and that used in second cloud clearing.
12.	**TotCld_4_CCfinal**	cloud fraction from IR retrieval
13.	**Water_Resid_Ratio**	ratio of residual in water retrieval to expected noise
14.	**Tdiff_IR_4CC1**	difference in lowest 2 km between startup state and IR retrievals

Note that two predictors from V5 have been omitted in V6 since they depended on the regression step which is no longer performed.

Note also that predictors 1, 5, and 6 require the AMSU channels, so they are omitted in the AIRS-only system.

The error estimate, $\delta \mathbf{x_i}$, for geophysical parameter ***i*** for a particular profile is:

$$\delta x_i = \sum_{k=1}^{14} M_{i,k} y_k$$

where $\boldsymbol{y_k}$ is the value of parameter ***k*** for a given case. There are separate matrices ***M*** for non-frozen ocean cases, land cases, and ice cases. The coefficients of these matrices were trained on two full days of retrievals for 9/29/04 and 2/24/07 using the ECMWF 3-hour forecast for that day as "truth".

Temperature error estimates at 6 levels (151 mb, 260 mb, 497 mb, 707 mb, 853 mb, 986 mb) and the total water error estimate are then used to predict errors via a second regression for water at 100 levels and for the cloud cleared radiances on a channel by channel basis. Since these seven predictors are themselves based only on the original 14 predictors and can be thought of as pseudo-principal components, these estimates are also based indirectly only on the original 14 predictors.

Error estimates for other quantities in the output files are either internal noise covariance estimates, varying by case, or ensemble error estimates, constant over all cases with a particular processing path. All error estimates are constrained not to fall beneath minimum values, and a few are constrained not to exceed impossibly high values.

A temperature error profile is defined by one of three cases, depending on the surface classification:

(O) Non-frozen ocean with liquid water covering >99% of FOV (**MWSurfClass** = 2)
(L) Land or coast cases (**MWSurfClass** = 0,1)
(F) Frozen cases, either land or ocean (**MWSurfClass** = 3,4,5,6,7)

The error profiles are defined by values at 70 mb, **PSurfStd**/2 (representative of the pressure at the middle of the atmosphere), and **PSurfStd**, and interpolated linearly in pressure to the 100 support levels. The values for determining **PBest** for the three cases are:

Case	TAirStdErr @70mb	TAirStdErr @PSurfStd/2	TAirStdErr @PsurfStd
O	3.0 K	0.6 K	1.0 K
L	3.0 K	0.6 K	1.0 K
F	3.0 K	0.6 K*	1.25 K

*0.65 K in AIRS-only system

A pressure level **PBest** is then set by comparing the temperature quality profiles with the level-by-level error estimates (at 100 levels) beginning downward from 70 mb. If the error estimate exceeds the quality profile for eight consecutive levels above 300 mb or three consecutive levels beneath 300 mb, **PBest** is set to the level above the first of those consecutive levels.

The values for determining **PGood** for the three cases are:

Case	TAirStdErr @70mb	TAirStdErr @PSurfStd/2	TAirStdErr @PsurfStd
O	3.0 K*	3.0 K*	3.0 K*
L	3.0 K*	2.0 K	2.0 K
F	3.0 K**	2.5 K	2.5 K

*3.25 K in AIRS-only system

**3.25 K daytime, 3.0 K at night in AIRS-only system

A pressure level **PGood** is then set by comparing the temperature quality profiles with the level-by-level error estimates (at 100 levels) beginning downward from 70 mb. If the error estimate exceeds the quality profile for eight consecutive levels above 300 mb or three consecutive levels beneath 300 mb, **PGood** is set to the level above the first of those consecutive levels. The thresholds for **PGood** are always looser than for **PBest**, so **PGood** will occur at a pressure deeper than or equal to **PBest**.

Over land and frozen conditions, the error estimates are large near the surface. In order to obtain adequate coverage, if the error estimates indicate **PGood** to be within six fine levels of the surface, we set **PGood** equal to **PSurfStd** and correspondingly the quality of the temperature retrieval at pressures between **PBest** and **PSurfStd** is set to 1.

3 Appendix I – Limit Check Bounds

Minumum PSurfStd = 490 hPa
Maximum PSurfStd = 1100 hPa

Minimum TSurfStd = 160 K
Maximum TSurfStd = 360 K

Level PressSupp (hPa)	MIN Tprof K	MAX Tprof K	MIN H2OCDSup cm^{-2}	MAX H2OCDSup cm^{-2}	MIN O3CDSup cm^{-2}	MAX O3CDSup cm^{-2}	MIN COCDSup cm^{-2}	MAX COCDSup cm^{-2}	MIN CH4CDSup cm^{-2}	MAX CH4CDSup cm^{-2}
0.0161	149.1	231.9	1.93E+14	1.54E+15	3.12E+13	2.06E+14	2.30E+14	7.02E+14	3.21E+13	4.56E+13
0.0384	160.7	243	3.88E+14	3.04E+15	5.56E+13	4.78E+14	1.45E+14	5.75E+14	6.42E+13	9.09E+13
0.0769	171.2	252.9	6.68E+14	5.50E+15	1.19E+14	9.00E+14	1.27E+14	5.97E+14	1.10E+14	1.55E+14
0.137	184	258.5	1.04E+15	9.15E+15	3.41E+14	1.72E+15	1.22E+14	5.93E+14	1.71E+14	2.41E+14
0.2244	204	264.6	1.51E+15	1.40E+16	7.20E+14	3.39E+15	1.10E+14	5.83E+14	2.41E+14	3.59E+14
0.3454	214.2	268.7	2.09E+15	2.01E+16	1.46E+15	6.74E+15	1.03E+14	6.25E+14	3.54E+14	5.25E+14
0.5064	212.2	273.8	2.78E+15	2.75E+16	2.58E+15	1.24E+16	1.06E+14	6.40E+14	5.12E+14	7.52E+14
0.714	210	279.2	3.58E+15	3.58E+16	4.29E+15	2.04E+16	1.17E+14	6.06E+14	7.26E+14	1.12E+15
0.9753	207.1	282	4.51E+15	4.50E+16	5.93E+15	3.10E+16	1.31E+14	5.81E+14	9.63E+14	1.67E+15
1.2972	203.6	282.7	5.55E+15	5.54E+16	8.28E+15	4.41E+16	1.46E+14	5.77E+14	1.33E+15	2.52E+15
1.6872	200.4	280.7	6.72E+15	6.71E+16	1.17E+16	6.05E+16	1.59E+14	6.37E+14	1.91E+15	3.85E+15
2.1526	198.7	278.9	8.01E+15	8.00E+16	1.44E+16	8.35E+16	1.70E+14	7.06E+14	2.69E+15	5.69E+15
2.7009	198.2	280.5	9.43E+15	9.42E+16	1.75E+16	1.12E+17	1.77E+14	7.64E+14	3.68E+15	7.94E+15
3.3398	200.6	281.7	1.10E+16	1.10E+17	2.10E+16	1.47E+17	1.77E+14	8.08E+14	4.98E+15	1.05E+16
4.077	205.3	279.9	1.27E+16	1.27E+17	2.55E+16	1.87E+17	1.79E+14	8.50E+14	6.55E+15	1.35E+16

Level PressSupp (hPa)	MIN Tprof K	MAX Tprof K	MIN H2OCDSup cm^{-2}	MAX H2OCDSup cm^{-2}	MIN O3CDSup cm^{-2}	MAX O3CDSup cm^{-2}	MIN COCDSup cm^{-2}	MAX COCDSup cm^{-2}	MIN CH4CDSup cm^{-2}	MAX CH4CDSup cm^{-2}
4.9204	209.1	277.4	1.45E+16	1.45E+17	3.07E+16	2.32E+17	1.83E+14	8.99E+14	8.39E+15	1.72E+16
5.8776	211.2	275.1	1.64E+16	1.64E+17	3.85E+16	2.80E+17	1.91E+14	9.56E+14	1.02E+16	2.14E+16
6.9567	208.7	273.3	1.85E+16	1.85E+17	5.03E+16	3.21E+17	2.03E+14	1.02E+15	1.22E+16	2.61E+16
8.1655	203.7	268.2	2.07E+16	2.07E+17	6.37E+16	3.57E+17	2.16E+14	1.09E+15	1.44E+16	3.14E+16
9.5119	200.6	259.5	2.31E+16	2.31E+17	7.88E+16	3.93E+17	2.34E+14	1.16E+15	1.68E+16	3.72E+16
11.0038	197.8	251.9	2.56E+16	2.56E+17	9.22E+16	4.28E+17	2.53E+14	1.22E+15	1.96E+16	4.35E+16
12.6492	195.2	250.3	2.82E+16	2.82E+17	1.02E+17	4.49E+17	2.69E+14	1.29E+15	2.27E+16	5.00E+16
14.4559	192.7	249.3	3.10E+16	3.09E+17	1.10E+17	4.49E+17	2.87E+14	1.35E+15	2.61E+16	5.62E+16
16.4318	190.4	248.3	3.39E+16	3.38E+17	1.19E+17	4.84E+17	3.07E+14	1.41E+15	2.96E+16	6.28E+16
18.5847	189.4	247.6	3.69E+16	3.68E+17	1.21E+17	5.17E+17	3.25E+14	1.48E+15	3.32E+16	6.98E+16
20.9224	190.2	247	4.00E+16	4.00E+17	1.24E+17	5.50E+17	3.47E+14	1.55E+15	3.70E+16	7.73E+16
23.4526	190.9	246.4	4.33E+16	4.33E+17	1.26E+17	5.70E+17	3.69E+14	1.62E+15	4.09E+16	8.52E+16
26.1829	189.3	245.8	4.68E+16	4.68E+17	9.78E+16	5.85E+17	3.94E+14	1.70E+15	4.51E+16	9.35E+16
29.121	187.8	245.3	5.03E+16	5.19E+17	7.79E+16	5.93E+17	4.37E+14	1.79E+15	4.97E+16	1.02E+17
32.2744	186.5	244.7	5.40E+16	5.74E+17	7.36E+16	6.06E+17	4.77E+14	1.89E+15	5.58E+16	1.10E+17
35.6505	185.2	244.2	5.78E+16	6.22E+17	4.41E+16	6.32E+17	5.10E+14	2.04E+15	6.25E+16	1.18E+17
39.2566	184.5	243.8	6.17E+16	6.71E+17	9.92E+15	6.52E+17	5.39E+14	2.20E+15	6.98E+16	1.28E+17
43.1001	184.8	243.9	6.57E+16	7.23E+17	5.03E+15	6.46E+17	5.72E+14	2.38E+15	7.76E+16	1.38E+17
47.1882	185.5	244	6.99E+16	7.77E+17	3.31E+15	6.34E+17	6.09E+14	2.57E+15	8.62E+16	1.48E+17
51.5278	186.1	243.5	7.42E+16	8.33E+17	2.95E+15	6.18E+17	6.67E+14	2.82E+15	9.57E+16	1.61E+17
56.126	186.7	242.8	7.86E+16	9.03E+17	3.00E+15	5.99E+17	7.35E+14	3.10E+15	1.06E+17	1.75E+17
60.9895	187.3	241.9	8.31E+16	9.79E+17	3.11E+15	5.87E+17	8.34E+14	3.47E+15	1.17E+17	1.90E+17
66.1253	187.9	240.6	8.78E+16	1.13E+18	3.28E+15	5.90E+17	9.65E+14	3.95E+15	1.29E+17	2.04E+17
71.5398	188.5	239.2	9.25E+16	1.49E+18	3.46E+15	5.90E+17	1.08E+15	4.46E+15	1.41E+17	2.20E+17
77.2396	189	238	9.74E+16	2.10E+18	3.65E+15	5.90E+17	1.20E+15	5.08E+15	1.54E+17	2.36E+17

Level PressSupp (hPa)	MIN Tprof K	MAX Tprof K	MIN H2OCDSup cm^{-2}	MAX H2OCDSup cm^{-2}	MIN O3CDSup cm^{-2}	MAX O3CDSup cm^{-2}	MIN COCDSup cm^{-2}	MAX COCDSup cm^{-2}	MIN CH4CDSup cm^{-2}	MAX CH4CDSup cm^{-2}
83.231	189.6	237.8	1.02E+17	2.83E+18	4.08E+15	5.86E+17	1.35E+15	5.76E+15	1.66E+17	2.51E+17
89.5204	190.2	237.6	1.07E+17	3.63E+18	4.59E+15	5.82E+17	1.53E+15	6.60E+15	1.78E+17	2.66E+17
96.1138	190.8	237.4	1.13E+17	4.65E+18	5.08E+15	5.74E+17	1.77E+15	7.97E+15	1.88E+17	2.80E+17
103.017	191.3	237.1	1.18E+17	5.75E+18	5.07E+15	5.66E+17	2.06E+15	9.74E+15	1.99E+17	2.93E+17
110.237	191.9	236.7	1.23E+17	7.09E+18	5.92E+15	5.55E+17	2.42E+15	1.20E+16	2.11E+17	3.09E+17
117.777	192.5	236.2	1.29E+17	9.36E+18	1.13E+16	5.42E+17	2.84E+15	1.50E+16	2.22E+17	3.25E+17
125.646	193	235.7	1.34E+17	1.19E+19	1.01E+16	5.28E+17	3.34E+15	1.85E+16	2.34E+17	3.41E+17
133.846	193.5	235.2	1.40E+17	1.47E+19	8.42E+15	5.12E+17	3.86E+15	2.25E+16	2.46E+17	3.58E+17
142.385	193.8	234.8	1.46E+17	1.99E+19	7.41E+15	4.94E+17	4.43E+15	2.69E+16	2.58E+17	3.75E+17
151.266	194	234.3	1.52E+17	2.62E+19	7.21E+15	4.73E+17	5.08E+15	3.16E+16	2.70E+17	3.92E+17
160.496	194.1	234.5	1.57E+17	3.28E+19	7.20E+15	4.56E+17	5.59E+15	3.65E+16	2.82E+17	4.08E+17
170.078	194.1	235.3	1.63E+17	4.09E+19	6.78E+15	4.48E+17	6.13E+15	4.17E+16	2.93E+17	4.25E+17
180.018	193.8	236.2	1.70E+17	5.18E+19	6.52E+15	4.40E+17	6.78E+15	4.70E+16	3.05E+17	4.42E+17
190.32	193.5	237	1.76E+17	6.32E+19	6.15E+15	4.30E+17	7.47E+15	5.24E+16	3.18E+17	4.60E+17
200.989	193.4	237.8	1.82E+17	7.52E+19	5.47E+15	4.19E+17	8.18E+15	5.79E+16	3.30E+17	4.78E+17
212.028	195.1	238.6	2.15E+17	9.10E+19	5.24E+15	3.93E+17	8.95E+15	6.33E+16	3.42E+17	4.95E+17
223.441	198	240.9	2.69E+17	1.10E+20	5.35E+15	3.54E+17	9.66E+15	6.85E+16	3.55E+17	5.13E+17
235.234	200.9	244.3	3.25E+17	1.33E+20	5.47E+15	3.28E+17	1.02E+16	7.34E+16	3.67E+17	5.31E+17
247.408	202.2	247.5	3.83E+17	1.60E+20	5.59E+15	3.08E+17	1.07E+16	7.80E+16	3.80E+17	5.49E+17
259.969	203.4	250.2	4.65E+17	1.92E+20	5.70E+15	2.88E+17	1.12E+16	8.23E+16	3.93E+17	5.67E+17
272.919	205.2	252.1	5.97E+17	2.29E+20	5.81E+15	2.66E+17	1.16E+16	8.62E+16	4.06E+17	5.85E+17
286.262	207	254	7.36E+17	2.72E+20	5.91E+15	2.44E+17	1.21E+16	8.98E+16	4.19E+17	6.03E+17
300	208.8	255.6	8.79E+17	3.24E+20	5.82E+15	2.22E+17	1.25E+16	9.32E+16	4.32E+17	6.21E+17
314.137	210.6	257	8.56E+17	3.75E+20	5.75E+15	1.98E+17	1.31E+16	9.66E+16	4.45E+17	6.40E+17
328.675	212.3	257.6	7.49E+17	4.48E+20	5.76E+15	1.74E+17	1.36E+16	9.98E+16	4.59E+17	6.58E+17

Level PressSupp (hPa)	MIN Tprof K	MAX Tprof K	MIN H2OCDSup cm^{-2}	MAX H2OCDSup cm^{-2}	MIN O3CDSup cm^{-2}	MAX O3CDSup cm^{-2}	MIN COCDSup cm^{-2}	MAX COCDSup cm^{-2}	MIN CH4CDSup cm^{-2}	MAX CH4CDSup cm^{-2}
343.618	213.1	258.1	6.26E+17	5.86E+20	5.79E+15	1.49E+17	1.66E+16	1.05E+17	4.72E+17	6.77E+17
358.966	213.9	258.5	6.43E+17	7.40E+20	5.81E+15	1.25E+17	1.86E+16	1.14E+17	4.86E+17	6.95E+17
374.724	214.7	259	7.59E+17	9.50E+20	5.83E+15	1.13E+17	1.97E+16	1.25E+17	4.99E+17	7.14E+17
390.893	215.4	259.6	8.78E+17	1.17E+21	5.84E+15	1.07E+17	2.08E+16	1.35E+17	5.13E+17	7.33E+17
407.474	215.9	260.5	9.93E+17	1.40E+21	5.85E+15	1.04E+17	2.20E+16	1.46E+17	5.27E+17	7.51E+17
424.47	216.4	261.3	1.11E+18	1.60E+21	5.86E+15	9.99E+16	2.32E+16	1.57E+17	5.41E+17	7.70E+17
441.882	217.3	263.1	1.29E+18	1.83E+21	5.86E+15	9.62E+16	2.45E+16	1.67E+17	5.54E+17	7.89E+17
459.712	218.5	265	1.53E+18	2.13E+21	5.86E+15	9.20E+16	2.58E+16	1.78E+17	5.68E+17	8.08E+17
477.961	219.7	267	1.93E+18	2.44E+21	5.86E+15	8.79E+16	2.71E+16	1.88E+17	5.82E+17	8.27E+17
496.63	220.8	268.9	2.87E+18	2.75E+21	5.91E+15	8.34E+16	2.83E+16	1.98E+17	5.96E+17	8.46E+17
515.72	222	270.7	6.31E+18	3.10E+21	5.68E+15	7.89E+16	2.96E+16	2.08E+17	6.10E+17	8.65E+17
535.232	223.2	272.2	9.53E+18	3.44E+21	5.42E+15	7.41E+16	3.09E+16	2.18E+17	6.24E+17	8.84E+17
555.167	224.7	273.8	1.06E+19	3.79E+21	5.30E+15	6.91E+16	3.21E+16	2.28E+17	6.38E+17	9.03E+17
575.525	226.2	275.3	1.17E+19	4.16E+21	5.16E+15	6.41E+16	3.33E+16	2.42E+17	6.52E+17	9.24E+17
596.306	227.9	276.8	1.32E+19	4.72E+21	4.86E+15	5.87E+16	3.46E+16	2.58E+17	6.66E+17	9.49E+17
617.511	229.6	279.5	1.49E+19	5.34E+21	4.53E+15	5.32E+16	3.58E+16	2.74E+17	6.80E+17	9.73E+17
639.14	231.4	283.6	1.65E+19	5.96E+21	4.37E+15	4.75E+16	3.70E+16	2.92E+17	6.94E+17	9.97E+17
661.192	233	287.5	1.82E+19	6.60E+21	4.28E+15	4.42E+16	3.83E+16	3.09E+17	7.08E+17	1.02E+18
683.667	234.1	290.9	1.96E+19	7.22E+21	4.27E+15	4.25E+16	3.95E+16	3.27E+17	7.22E+17	1.04E+18
706.565	235	293.9	2.14E+19	8.01E+21	4.14E+15	3.92E+16	3.69E+16	3.45E+17	7.37E+17	1.07E+18
729.886	236.2	297.2	2.33E+19	8.97E+21	4.07E+15	3.85E+16	3.68E+16	3.63E+17	7.50E+17	1.09E+18
753.628	237.2	300.9	2.53E+19	9.69E+21	4.01E+15	3.87E+16	3.72E+16	3.81E+17	7.64E+17	1.11E+18
777.79	238.2	304.8	2.82E+19	1.03E+22	3.86E+15	3.90E+16	3.75E+16	3.99E+17	7.78E+17	1.13E+18
802.371	238.7	309	3.13E+19	1.09E+22	3.76E+15	3.92E+16	3.83E+16	4.16E+17	7.92E+17	1.15E+18
827.371	239.2	312.5	3.45E+19	1.15E+22	3.73E+15	3.93E+16	4.19E+16	4.32E+17	8.06E+17	1.17E+18

Level PressSupp (hPa)	MIN Tprof K	MAX Tprof K	MIN H2OCDSup cm^{-2}	MAX H2OCDSup cm^{-2}	MIN O3CDSup cm^{-2}	MAX O3CDSup cm^{-2}	MIN COCDSup cm^{-2}	MAX COCDSup cm^{-2}	MIN CH4CDSup cm^{-2}	MAX CH4CDSup cm^{-2}
852.788	239.8	311.1	3.81E+19	1.31E+22	3.78E+15	3.94E+16	4.42E+16	4.48E+17	8.20E+17	1.19E+18
878.62	240.3	310	4.39E+19	1.49E+22	3.84E+15	3.95E+16	4.65E+16	4.63E+17	8.35E+17	1.21E+18
904.866	240.2	310	5.01E+19	1.68E+22	3.89E+15	3.95E+16	4.69E+16	4.76E+17	8.49E+17	1.22E+18
931.524	239.6	310	5.80E+19	1.89E+22	3.90E+15	3.95E+16	4.72E+16	4.88E+17	8.63E+17	1.24E+18
958.591	239.1	310	5.47E+19	2.16E+22	3.84E+15	3.92E+16	4.75E+16	4.99E+17	8.78E+17	1.25E+18
986.067	238.6	310	4.92E+19	2.46E+22	3.73E+15	3.94E+16	4.77E+16	5.09E+17	8.92E+17	1.27E+18
1013.95	238.2	310	4.37E+19	2.77E+22	3.62E+15	3.97E+16	4.78E+16	5.17E+17	9.07E+17	1.29E+18
1042.23	237.8	310.7	3.81E+19	3.08E+22	3.61E+15	4.00E+16	4.80E+16	5.23E+17	9.22E+17	1.31E+18
1070.92	237.4	313.4	3.24E+19	3.39E+22	3.65E+15	4.10E+16	4.81E+16	5.27E+17	9.36E+17	1.33E+18
1100	237.1	316	2.66E+19	3.71E+22	3.70E+15	4.50E+16	4.83E+16	5.30E+17	9.45E+17	1.36E+18